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AUTHOR Sequrson, Jack
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ABSTRACT

It has been suggested that the weight reduction practices of wrestlers results in kidney and liver problems. To observe the effect of wrestlers' weight reduction, diagnostic tests for kidney and liver problems were done on the blood and urine samples of 22 college wrestlers over the course of a wrestling season. Results obtained after reduction to wrestling weights were compared with those obtained when there was no special effort to reduce. Results indicated that (1) there was no evidence of liver damage or impairment; (2) no trend toward significant change was seen in any test during the study; and (3) all changes seen following reduction to minimal weight disappeared after periods of normal eating and drinking for several days. (2M)

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THE EFFECT OF WEIGHT REDUCTION ON BLOOD AND URINE MEASUREMENTS OF COLLEGE WRESTLERS

Author: Jack Segurson, PhD, Animal Physiology, The University of Arizona, Tucson, Arizona 85721

Mailing address: Route 18, Box 711 P, Tucson, Arizona 85715

Telephone (602) 749-3430

RUNNING HEAD:

WEIGHT REDUCTION OF COLLEGE WRESTLERS

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INTRODUCTION

To this day the question of the effect of weight reduction on wrestlers remains obscure. Those who are close to wrestling, coaches and participants, generally consider it advantageous, while other persons, including many physicians and physiologists, regard the practice as harmful and possibly dangerous (1,25).

In pursuit of the answer, researchers have investigated the effect of weight reduction on performance (21,27), cardio-vascular responses (30), respiratory function (24), morphological changes (29), and urinary excretion (26,34) without the emergence of a clear pattern — favorable or unfavorable.

The need has long prevailed for screening the blood obtained from wrestlers at minimal body weight with a broad spectrum of tests to learn more about the problem. Accordingly, the 28 parameters of the blood and 18 of the urine (table 1) were measured for this purpose.

Table 1. Measurements

METHODS

The subjects were 22 members of a college wrestling team whose physical characteristics are listed in table 2. Informed consent was obtained

Table 2. The subjects.

for testing their blood and urine on seven occasions according to the procedure listed in table 3. Results obtained at reduced weight were compared with those obtained while the subjects were not reducing.

Table 3. Procedure for the experiment.

Weight reductions ranged from 3.0% to 12.7%, mean 6.9%, of body weight on Monday of the week of the reduction. The amount of weight removed in each case was that which was necessary for the individual to reach the upper limit of his weight class. Weight was removed through a combination of food restriction, water restriction, work, sweating, and possibly other means. For fear of excluding some practice that could have yielded meaningful information, neither the method of weight reduction nor the ingestion of food and water were regulated. The only restriction imposed was the wearing of light clothing during wrestling practices. Practices were held in a relatively open area that could not be heated to high temperatures.

Changes were determined by two criteria: 1) Results that differed significantly ($p<0.05$) at reduced weight as determined by the Student's t test and 2) changes that fell outside the normal clinical range (NCR)[1].

Results obtained from an individual subject more than one time after the same weight reduction as well as the follow-up test were randomly selected for only one of such occasions. The purposes were 1) to avoid weighting the results and 2) to limit the number of degrees of freedom which influence the interpretation of the Student's t test for significance.

Blood was taken from an antecubital vein without stasis in commercially prepared tubes (Vacutainer, Becton-Dickinson, Rutherford, N. J.) and immediately thereafter the blood was either centrifuged, allowed to clot, or retained as whole blood, according to purpose. The Auto-Chemist (Stockholm, Sweden) was used for determination of alkaline phosphatase, bilirubin, BUN, albumin, cholesterol, calcium, chloride, creatinine, glucose, LDH, phosphorus, potassium, SGOT, sodium, thyroxine, total protein, and uric acid. Acid-base values were determined by the Astrup technique (Radiometer, Copenhagen, Denmark).

Prior to two weigh-ins, urine was collected for 24 hours in plastic containers which were kept covered and refrigerated. Volumes were measured and aliquots taken for the remaining tests. At other times fresh specimens were obtained immediately before testing. Quantitative tests of the urine were done by the osmometer, the hydrometer, the pH meter, and the Auto-Chemist. Qualitative tests were done by reagent strips (Bili-Labstix, Elkhart, Indiana) for pH, protein, glucose, ketones, bilirubin, and occult blood. Microscopic examination was done for bacteria, casts, crystals, epithelial cells, erythrocytes, and leucocytes. Visual examination was done for color and transparency.

RESULTS

At reduced weight significant change occurred in two tests, serum uric acid and serum creatinine (table 4). Serum uric acid increased from 5.63 mg/100 ml to 7.49 at reduced weight and serum creatinine increased from 1.18 mg/100 ml to 1.34.

Table 4. Tests which changed significantly at reduced weight.

The results of several other tests at reduced weight departed either from the NCR or from normal values. Had there been the opportunity for their measurement while the subjects were not reduced, significant change may have been seen. These tests were the acid-base group (table 5), urine creatinine, blood and urine osmolarity, and urine volume (table 6).

Table 5. Acid-base values of the blood at reduced weight.

Table 6. Test results outside the NCR.

Urine volume and urine osmolarity were compared between subjects who had reduced and those who were to compete without reducing. As expected, the mean urine volume of those who had not reduced was greater, 612 ml/24 hr compared with 474.3 ml/24 hr for those who had reduced. However, the osmolarity of both groups was of the same order, 1231.75 mOsm/liter without reduction and 1223.85 mOsm/liter with reduction.

Of the products of urinary sedimentation, only epithelial cells appeared more frequently at reduced weight at which they were seen in the urine of eight subjects while only once among those who had not reduced.

DISCUSSION

Hypohydration at reduced weight was indicated by reduced urine volume along with increased osmolarity of serum and urine, and increased levels of nitrogenous compounds in blood serum (creatinine, urea, and uric acid). The change in BUN was neither significant nor a departure from the NCR, however, there was only one case in which the BUN failed to rise following weight reduction. Changes in serum electrolytes have been reported during water deficit (4,20,33), yet among these subjects no change was seen in the electrolytes measured.

The increase in uric acid was probably due more to food restriction and/or strenuous work rather than water deficit. The acid-base results obtained after weight reduction support this view. An increase in serum uric acid requires either increased production or decreased excretion (14). Increased production stemming from either food restriction (15) or strenuous work (22) is doubtful, therefore, the change was likely the result of a decreased rate of excretion. A decrease in uric acid excretion has been attributed to interference with tubular transport (9)

by such organic acids as beta-hydroxybutyrate and lactate (13). Uric acid rises during the first 5-7 days of fasting (16) whereas, with work, the clearance of uric acid is reduced as lactic acid increases, and this may be seen in ten minutes or less. Following the cessation of work, uric acid clearance returns to normal in approximately one hour (2).

Although serum uric acid increased significantly at reduced weight, the increase correlated poorly with the percentage of weight reduced (r=.15) suggesting that the rise in uric acid was of the same order for all weight reductions. The reason for this is not known but several possibilities are suggested:

(Figure 1)

Figure 1. Effect of weight loss on serum uric acid levels.

1. The period of food restriction was too short because healthy adult males after five days of fasting had a mean serum level of 12.8 mg/100 ml (5) while the level of the wrestlers, 7.49, is reached in 2-3 days.

2. Ingestion of food other than fat tends to lower the uric acid level in the serum (10,16).

3. Sweat glands may have served as an accessory excretory organ. Lyburn (18) has estimated that the clearance of uric acid through sweat may equal that of 1/3 of a kidney.

4. Weight losses may have been principally due to hypohydration which has a minor effect on uric acid.

Acidosis as suggested by the acid-base values obtained at reduced weight can be caused by increased lactic acid (2) or keto acids (10) as both require buffering. It is not an expected outcome of hypohydration (17,20). Lactic acid and keto acids, at times, have a reciprocal relationship in that strenuous exercise may increase lactate levels while at the same time temporarily lowering the circulating keto acids (6,7).

Creatinine, both serum and urine, reached high levels in these

subjects, serum 1.34 mg/100 ml and urine 331.5 mg/100 ml which compares closely with the 335 mg/100 ml of Iowa high school wrestlers (34). This may have been due to increased creatinine production which can be caused by the extensive loss of lean body mass associated with rapid weight reduction (11). Another possibility is that the creatinine values obtained were higher than the true values due to the influence of either pH or ketone bodies on the color reaction that takes place between creatinine and sodium picrate in the Jaffe reaction used for its determination (3,23).

It is not known why the urine osmolarity was of the same order among the subjects who were to compete at reduced weight as those who were to compete without weight reduction. Perhaps it is a spurious result. On the other hand there is the suggestion that the factors surrounding competition may have been responsible.

The greater frequency of epithelial cells seen in the urine at reduced weight suggests several possibilities such as strenuous work (12), irritation of the gastro-intestinal tract (28), renal stress (31), or, simply, normal conditions.

The results of this investigation confirm a state of hypohydration at reduced weight and, further, suggest food restriction. The responses of wrestlers to hypohydration and food restriction are similar to those which have been reported for lean, adult males and for the therapeutically starved obese.

The obtained evidence does not support a conclusion of physical damage or other health problem as a result of weight reduction as practiced by these subjects. Unanswered is the long-term effect of frequent high levels of serum uric acid.

Improvement during fasting has been seen with diabetes, hypertension, pulmonary function, cardio-vascular responses, psoriasis, cholesteremia, allergy, epilepsy, rheumatic fever, and resistance to colds (8,10). Jockeys who may ride at reduced weight for most of their careers have recently been found to possess extraordinary fitness (19). Suggested, therefore, is investigation of the positive side of weight reduction for benefits that may accrue.

FOOTNOTES

1. Normal clinical ranges (NCR), which are widely used in clinical medicine, consist basically of $\pm$ 2 standard deviations. They may, however, be slightly modified by such factors as test procedure, equipment, ambient conditions, and empirical results (28). Sources of the NCR's used in this study were the United Medical Laboratory for tests done with the Auto-Chemist (30) and Wallach (32) for the remaining tests.

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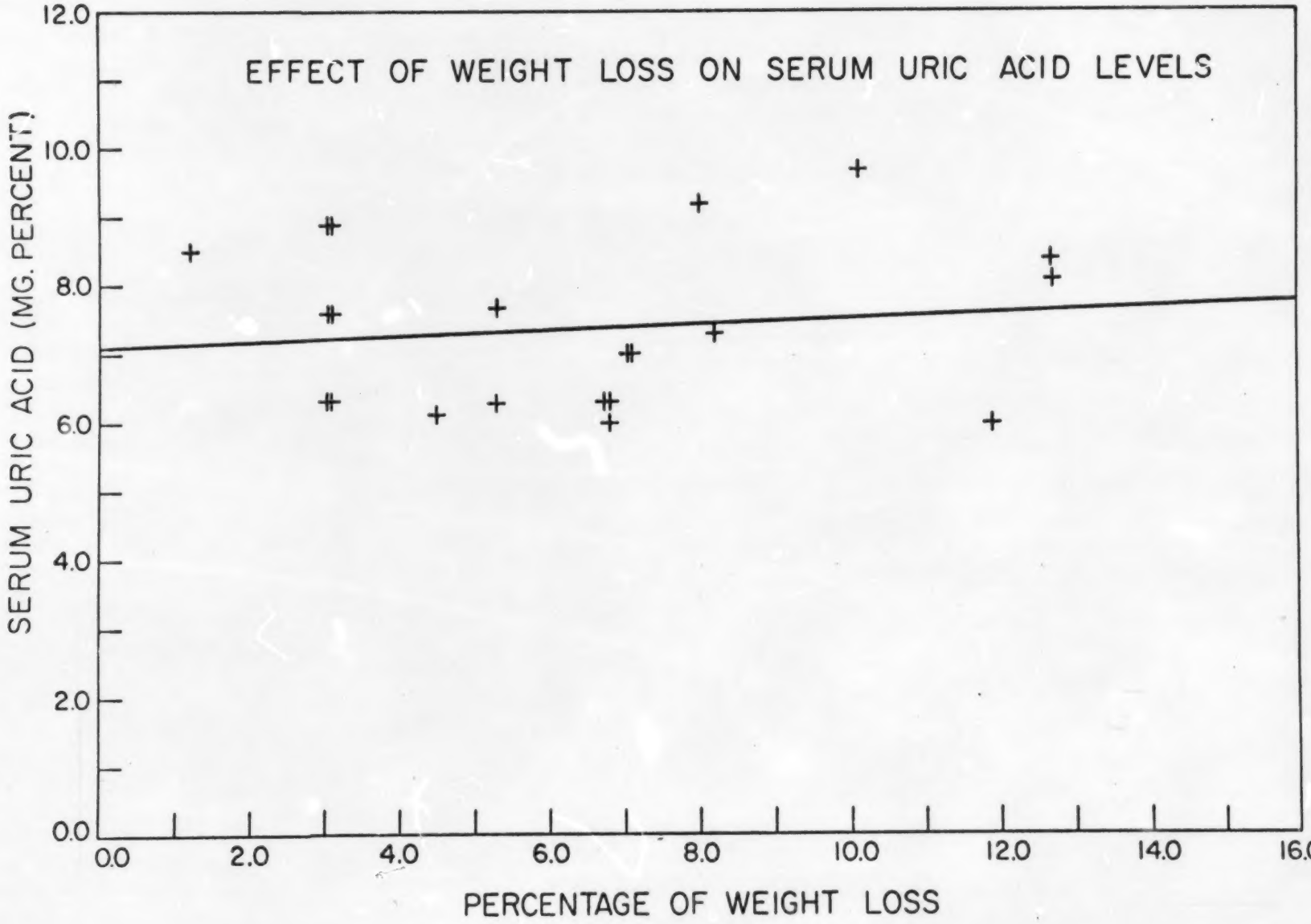
EFFECT OF WEIGHT LOSS ON SERUM URIC ACID LEVELS
SERUM URIC ACID (MG. PERCENT)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
PERCENTAGE OF WEIGHT LOSS

Figure 1.

Table 1. Measurements.

Blood	Urine
Acid-Base	**Quantitative**
pH	Creatinine
PCO_2	Osmolality
Total CO_2	Specific gravity
Buffer base	Volume
Base excess	
Standard bicarbonate	**Semi-quantitative**
Actual bicarbonate	Microscope
Electrolytes	Bacteria
Calcium	Casts
Chloride	Crystals
Phosphorus	Epithelial cells
Potassium	Erythrocytes
Sodium	Leucocytes
Enzymes	Occult blood
Alkaline phosphatase	**Qualitative**
LDH	Reagent strip
SGOT	Bilirubin
Miscellaneous	Blood
Bilirubin	Glucose
Cholesterol	Ketones
Glucose	pH
Osmolarity	Protein
Thyroxine	Visual
Protein	Color
Total	Transparency
A/G value	
Albumin	
Globulin	
Products of Protein Metabolism	
BUN	
Creatinine	
Creatinine clearance	
Uric acid	

Table 2. Physical characteristics of the subjects.

Subject	Age	Height in.	Body Weight in Pounds			Surface Area m_2	Years of Wrestling	Years of Reduction
			Pre-Season	Season	Competition			
1	19	72	190	190	190	2.10	5	0
2	18	67	140	139	134	1.75	5	3
3	20	71	195	190	177	2.10	5	3
4	18	70	170	170	158, 167	1.95	5	5
5	20	69	195	189	177, 190	2.06	5	3
6	18	70	190	190	190	2.04	5	0
7	18	71	172	169	167	1.98	5	3
8	18	70	164	163	150, 158	1.91	5	4
9	22	71.5	200	185	177	2.12	6	6
10	19	69.5	174	175	158, 167	1.96	6	6
11	26	66	150	143	134	1.76	13	12
12	19	66.5	146	146	134, 142	1.75	4	4
13	22	65	135	126	118	1.66	8	5
14	18	69.5	156	158	142, 150	1.86	5	3
15	19	69	168	168	167	1.92	5	2
16	18	65	120	119	118	1.58	5	0
17	20	65.5	145	144	126	1.73	6	4
18	18	73	202	202	190, HVY	2.17	5	0
19	20	66	149	149	142	1.76	7	4
20	18	66	143	143	142	1.73	5	3
21	18	72	176	176	177	2.01	5	2
22	18	69	162	162	158	1.88	1	0

Table 3. Procedure for the experiment.

Sample	Date	Collection Time	Weigh-in Time	Event	Weight of Subjects
1	09/28/72	0800-1100	1700	tournament	some reduced, some normal
2	11/30/72	1800	0700	tournament	some reduced, some normal
3	12/04/72	0800-1100			replenished[a]
4	01/16/73	1415	1430	dual meet	reduced
5	01/17/73	0800-1100			replenished
6	02/02/73	1430	1430	dual meet	reduced
7	02/05/73	0800-1100			replenished

a. Replenished = food and water ad libitum.

Table 4. Tests which changed significantly at reduced weight.

Test	n	Mean	S.D.	Sig.	NCR
Serum uric acid					3.6–7.2 mg/100 ml
Food and water ad lib.	16	5.63	0.64		
Reduced weight	16	7.49	1.28		
		+1.86		p=0.0001	
Serum creatinine					1.0–1.8 mg/100 ml
Food and water ad lib.	16	1.18	0.21		
Reduced weight	16	1.34	0.18		
		+0.16		p=0.021	

Table 5 . Acid-base values of the blood at reduced body weight

Subject	pH	P_{CO_2} (mm Hg)	Base Excess (mEq/l)	Buffer Base (mEq/l)	Standard HCO_3 (mEq/l)	Actual HCO_3 (mEq/l)	Total CO_2 (mm Hg)	Weight Reduced (%)
Norms	7.40	40	0	44-48	24.1	24.1	25.3	
S-3	7.40	37.5	-1	45.0	23.0	22.5	23.5	6.8
S-4	7.40	41.0	+1	47.0	24.5	24.5	25.5	7.0
S-8	7.36	41.0	-2	44.0	22.0	22.0	23.5	8.0
S-14	7.36	32.0	-6	39.0	19.0	17.5	18.5	10.1
S-17	7.40	33.0	-2	43.5	21.0	21.0	22.0	12.7

Table 6. Results outside the NCR.

Test	n	NCR	Mean	Range
Creatinine clearance	8	90–130 ml/min	92.25	51.0–135.0
Creatinine, urine	8	15–25 mg/kg/day	27.22	17.99–33.97
Osmolarity, blood	5	285–295 mOsm/liter	309.60	289–375
Osmolarity, urine	12	50–1200 mOsm/liter	1223.85	1010–1485
Volume, urine	10	500–1500 ml/24 hr	474.30	210.0–845.0